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GB A 2136952

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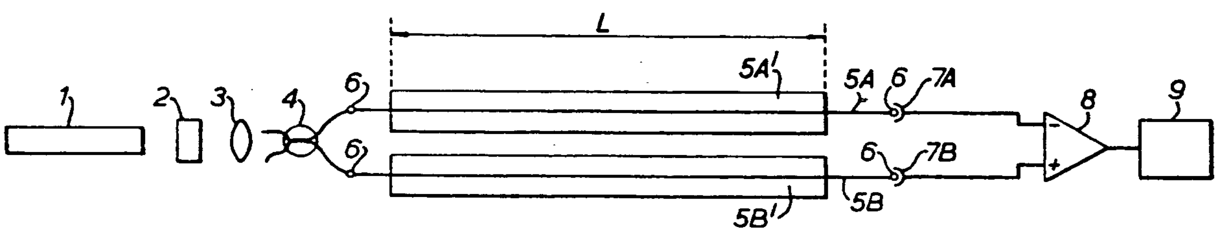
(54) **Magnetometer**

(57) The magnetometer comprises a common light source 1 which feeds two Fabry Perot interferometers selected so that one experiences a path length increase due to a magnetic influence when the other experiences a path length decrease due to the same magnetic influence. A comparison between outputs of the two interferometers, as detected by photo detectors 7A,7B thus gives a measure of the magnetic field strength. This is independent of frequency or phase variations of the light source since such variations affect the two interferometers equally and these effects are therefore cancelled out in the comparison process. As shown, each interferometer comprises an optical fibre 5A,5B with half-silvered ends 6, one being clad in positive magnetostrictive material 5A′ and the other in negative magnetostrictive material 5B′.



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The drawing(s) originally filed was/were informal and the print here reproduced is taken from a later filed formal copy.

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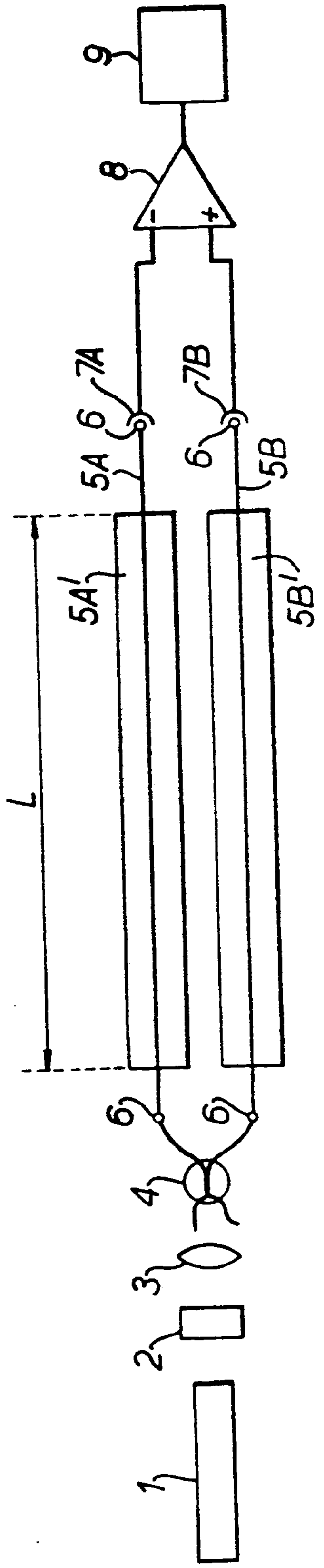

SPECIFICATION

A magnetometer

This invention relates to a magnetometer, i.e., an instrument for measuring magnetic field strength. It particularly relates to a magnetometer utilising the magnetostrictive effect i.e., the change in dimensions which some materials experience when subjected to a magnetic field. This is used to change a path length for optical or other energy so as to produce an interference effect which is used to measure the magnetic force.

The most sensitive type of magnetostrictive magnetometer employs what is known as a Fabry Perot interferometer which is a device in which coherent radiation, e.g., from a laser, is passed repetitively along an optical path and in which an interference effect between components of the light which have passed along the path different numbers of times is observed. This interference effect can be used to measure changes of the path length which, if produced using the magnetostrictive effect, are indicative of changes in magnetic field strength.

It is now realised that the sensitivity of magnetometers employing a Fabry Perot interferometer can be so good that the principal limitation to accuracy is imposed by the existence of variations in the phase or frequency (known as phase noise or frequency jitter) of the source of radiation. The invention arose in an endeavour to overcome this problem.

This invention provides a magnetometer comprising two Fabry Perot interferometers defining respective paths, the paths being constructed or arranged so that the length of one path increases relative to the other in response to the application of a magnetic field, the magnetometer including a common energy source arranged to feed radiation or waves into both paths and further including means for comparing the outputs of the interferometers.

Because both interferometers receive energy from a common source each is affected substantially equally by the phase noise or frequency jitter. This undesired effect can thus be eliminated by comparing the outputs of the interferometers.

The two paths will preferably be optical guides for light, infra-red or ultra violet radiation. They can possibly be made of substances which are themselves magnetostrictive though preferably they are attached to a magnetostrictive material since magnetostrictive materials are not as a rule optically transparent. There are many ways in which a suitable attachment can be effected. For example an optical fibre can be coated in a magnetostrictive material applied either directly to the optically conducting material or with the interposition of the usual protective layer formed on optical fibres. An alternative possibility is for the optical fibre or other member which defines the path to be attached by adhesive to a piece of magnetostrictive material.

Whilst each of the aforementioned paths is preferably an elongate guide such as an optical fibre, this enabling a long path length to be easily obtained, other possibilities exist. For example a solid transparent plate, sheet or block could be used with the light being reflected repetitively off opposite sides.

A differential expansion and contraction of the path lengths is needed in order that the result of comparing the two outputs should result in a non-zero value from which the magnetic strength measurement can be obtained. This differential expansion and contraction can be achieved by using different magnetostrictive materials in which case it is preferable to select materials such that when one expands the other contracts. An alternative technique is to use identical materials but to arrange the paths at an angle, preferably 90° to each other. This can be expected to achieve a similar effect since an elongate magnetostrictive element whose length is increased when aligned with a magnetic field can be expected to experience a reduction in length when arranged laterally with respect to the magnetic field. In such arrangements where the paths are arranged laterally with respect to each other they could be formed by optically conducting fibres fixed to or embedded in a common body of magnetostrictive material.

In one form the invention can be used in the construction of an instrument for measuring magnetic field gradients. In such an instrument the magnetostrictive elements can be made of identical material and be arranged with their lengths parallel to but spaced from each other. The difference between the output of the two interferometers will then be representative of the difference in magnetic field strength between the two parallel lengths and therefore of the magnetic field gradient.

One way in which the invention may be performed will now be described by way of example with reference to the accompanying schematic drawing of a magnetometer constructed in accordance with the invention.

Referring to the drawing a laser diode 1 generates coherent light which it directs through an isolator 2 the purpose of which is to prevent reflected light being returned to the laser diode. The light is then focused by a lens 3 onto an input port of a directional coupler 4. This splits the light into two parts which pass into two optical paths defined by glass fibres 5A and 5B. Each of these paths carries, along a length L a coating of positive and negative magnetostrictive materials respectively. These materials are indicated at 5A′ and 5B′. The two optical fibres 5A and 5B have half silvered ends 6. At the ends of

the fibres remote from the source 1 are respective photo detectors 7A and 7B. Each photo detector receives light which has travelled along the fibre an odd number of times e.g., 1, 2, 5 etc. Changes in the length 2L which are significant compared with the wavelength of the light will therefore, because of interference effects, produce a noticeable change in the amplitude of the light as seen by the photo diode. The changes will be in opposite directions at the two photo diodes and thus, by comparing their outputs in a comparator 8 a measure of the magnetic field strength in a direction parallel to the length of the fibres 5A and 5B can be obtained e.g., using a signal processor 9.

CLAIMS

1. A magnetometer comprising two Fabry Perot interferometers defining respective paths, the paths being constructed or arranged so that the length of one path increases relative to the other in response to the application of a magnetic field, the magnetometer including a common energy source arranged to feed radiation or waves into both paths and further including means for comparing the outputs of the interferometers.

2. A magnetometer according to claim 1 in which the two paths extend in the same direction and are associated with magnetostrictive materials having opposite magnetostrictive properties such that one extends when the other contracts.

3. A magnetometer according to claim 1 in which the interferometers are identical but spaced apart so that the result of the comparison is indicative of a magnetic field gradient in the direction of spacing.

4. A magnetometer according to claim 1 in which the two paths extend traverse to each other.

5. A magnetometer substantially as described with reference to the accompanying drawing.

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